BRICC Program Package
v 1.3

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(Dated: December 22, 2004)

Abstract

The BRICC program package consists of BLDBRICC and BRICC. The program BLDBRICC builds a direct access file from the tabulated electron and electron–positron pair conversion coefficients, and from the E0 electronic factors. BRICC can be used in different ways: as an interactive tool to interpolate conversion coefficients and E0 electronic factors; as an ENSDF evaluation tool. The program will prepare new ENSDF records (GAMMA and GAMMA continuation) and it also can be used to merge the new cards into existing ENSDF data sets.

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I. THE ENSDF FILE

The Evaluated Nuclear Structure Data File (ENSDF), is a computer-based file system designed to store nuclear structure information. It is maintained by the National Nuclear Data Center (NNDC) at Brookhaven National Laboratory for the international Nuclear Structure and Decay Data Network. The format for ENSDF was first designed by W. B. Ewbank and M. R. Schmorak [1978EwXX] at the Nuclear Data Project, Oak Ridge National Laboratory.

The ENSDF file usually contains a number of data sets, each data set refers to a particular reaction or decay mode of a nucleus. Adopted level and gamma-ray properties for each nuclide are kept in a separate data set. The data sets are composed of 80–character records, or as are called originally, in cards, referring to the 80 column IBM punch cards. The most up–to–date description of the ENSDF files is given by J.K. Tuli [2001TuXX]. Throughout this manual we will frequently make reference to this document. Spectroscopic information is kept in predefined fields of the 80 character long records. These fields are marked with bold typeface. For example the numerical value of the total conversion coefficient, store in the **ICC** field of the **GAMMA** record, is α_{tot}.

This document describes the use of the utility program, BldBrIcc (Sec V) to generate the direct access and index files and the interactive use of the BrIcc (Sec VI) and its use as an evaluation tool (Sec VI B and VI C).

II. GAMMA TRANSITIONS RECORDS

The GAMMA and the GAMMA continuation records, designed to hold the spectroscopic information on nuclear transitions, are particularly important to the BrIcc program. A short description of the fields of the **G** records (see Table II) is given in this section. The adopted procedures, relevant to BrIcc are described in Sec III.

A. GAMMA records

Transition energy (E) and uncertainty (DE) fields: The transition energy, **E** (E_γ) and the symmetric uncertainty, **DE** (ΔE_γ) are given in keV. In a relatively small cases, asymmetric uncertainty values are given in the GAMMA continuation record using the ENSDF dictionary term, DE= with two, maximum two digits integer numbers. For example E=12.4, DE=+1-2 will correspond to a transition energy of $E = 12.4^{+0.1}_{-0.2}$ keV. The asymmetric uncertainties of E_γ will be referred as ΔE_H and ΔE_L.

Photon Intensity (RI) and uncertainty (DRI): The experimental photon intensity is given in the **RI** and in the **DRI** fields. The numerical values are I_γ and ΔI_γ. For pure E0 transitions, are treated differently, **RI** is blank, but the total intensity, **TI** is given (see below).

Multipolarity (M) field: can contain a maximum of 3 multipolarities, including E0,E1,E2,...E6,M1,M2,...M6 (corresponding to electric monopole, electric/magnetic dipole, etc) or D,Q,O,... (dipole, quadrupole, etc.). To mark mixed and doubtful multipolarities the following characters are used [ ] ( ) + and ,(coma). Some typical combinations are listed in Table IV. In the case of mixed multipolarity the lowest two multipole orders will be used by the program BrIcc to calculate the conversion coefficient. *E0+M1+E2* transitions are

treated differently. The *M1* or *E2* multipolarity is considered first and the *E0* becomes last. If any non-standard character is present in the **M** field, the multipolarity (and mixing ratio) will be omitted.

Mixing Ratio (MR) field: The multipole mixing ratio, δ is defined as the ratio of two absolute transition amplitudes [1974AlXX]:

$$\delta(\pi' L'/\pi L) = \frac{\gamma(\pi' L')}{\gamma(\pi L)} \tag{1}$$

The + or - character in the **MR** field indicates, that the sign of the mixing ratio is known.

In some cases three multipolarities can mix and in a similar way to Eqn. 1 one can define:

$$\delta(\pi'' L''/\pi' L') = \frac{\gamma(\pi'' L'')}{\gamma(\pi' L')} \tag{2}$$

Valid combination of mixed multipolarities ($0 \leq L \leq 5$) are include:

	$\Delta\pi = +1$			$\Delta\pi = -1$	
πL	M1	M1	M3	E1	E3
$\pi' L'$	E2	E2	E4	M2	M4
$\pi'' L''$	M3	E0	M5	E3	E5

In the case of *E0+M1+E2* transitions the **MR** field is reserved for the $\delta(E2/M1)$ mixing ratio. The *E0,E2* mixing ratio,

$$q^2(E0/E2) = \frac{I_K(E0)}{I_K(E2)} \tag{3}$$

can be specified in the GAMMA continuation record as **MRKE0/E2**. *This term yet to be defined in the ENSDF dictionary and manual.* Conversion coefficients for mixed multipolarity transitions with E0 component (M1+E2+E0, M1+E0, E2+E0, etc.) can not be calculated by BrIcc and no new **G** and/or "**S G**" records are generated.

Similarly, mixed transitions with three multipole components of E1-E5, M1-M5 can not be calculated and no new **G** and/or "**S G**" records are generated. Correct conversion coefficients can be entered manually on new **G** and/or **S G** records if there is sufficient information is known on all mixing ratios involved.

Mixing Ratio Uncertainty (DMR) field: A single integer or two integers with + and - signs in the **DMR** field will be interpreted as symmetric or asymmetric uncertainty values, respectively. In some cases the **DMR** field contains *GE, GT, LE, LT* or *AP* strings indicating a limit on **MR** or that **MR** is an approximation. Some examples of the coding and interpretation of the **MR** and **DMR** field are given in Table IV. The asymmetric uncertainties of δ will be referred as $\Delta\delta_H$ and $\Delta\delta_L$.

Total Conversion Coefficient (CC) and Uncertainty (DCC) fields: If the multipolarity and mixing ratio are known, the total conversion coefficient is calculated by the BrIcc program. Numerical value of **CC** and the symmetric uncertainty is labeled as α_{tot} and $\Delta\alpha_{tot}$. **CC** will be placed onto the new **G** record if $\alpha_{tot}/(1+\alpha_{tot}) \geq 10^{-4}$, otherwise it will be placed to the "**S G**" GAMMA continuation record. If **CC** is derived purely from theoretical conversion coefficient the **DCC** field should be left blank on the **G** record. See Sec. III for the calculation method used.

Relative Total Intensity (TI) and Uncertainty (DTI) fields: In the case if the photon intensity, I_γ, and the total conversion coefficient, α_{tot} are known, the relative total intensity, I_{tot} is defined as

$$I_{tot} = I_\gamma * (1 + \alpha_{tot}). \quad (4)$$

For pure *E0* transitions I_{tot} is the sum of electron conversion (I_K, I_{L1}, ...) and pair conversion I_{IPF} intensities. Higher order effects of electromagnetic transitions are usually neglected.

If the **TI** is given, values of the K/T, L/T, etc. intensity ratio will be placed in the **S G** records, providing that the value $\geq 10^{-4}$.

B. GAMMA continuation records

Table III gives the sort description of the GAMMA continuation records. There are two basic type of GAMMA continuation records.

1. *"2 G" GAMMA continuation records*

Any character, other than 1 or S in column 6 can be used to create a GAMMA continuation record. This record is intended to store quantities (see Table III), which are not defined in the **G** record. The BrIcc program will scan these records to read numerical values of **DE** and **MRKE0/E2**. *This term yet to be defined in the ENSDF dictionary.* "**2 G**" records are created by the ENSDF evaluators.

2. *"S G" GAMMA continuation records*

This type of record, with a character 'S' in column 6, is a special type of continuation record which flags the Nuclear Data Sheets production code to suppress the data contained on it for the publication. BrIcc generates "**S G**" records and the data on these records are used by other programs. Conversion coefficients and uncertainties are calculated as described in Sec. III. Electron to total intensity ratios are calculated from the conversion coefficients.

The BrIcc program will scan the "**S G**" records of the input ENSDF file. A warning message will be inserted into the calculation report file if any non-standard dictionary term is found. The non-standard quantity will be placed on a new "**S G**". See Table III for the list of dictionary terms expected in "**S G**" records. Please note that with the exception of RadList, none of the ENSDF utility programs extract any numerical values from the "**S G**" records.

III. CALCULATION OF CONVERSION COEFFICIENTS

Electron conversion coefficients (α_K, α_{L1}, α_{L2}, ... etc.) and electron–positron pair conversion coefficient (α_{IPF}) are calculated by BrIcc. Values for pure multipolarity transitions are obtained by a cubic spline interpolation of the tabulated values (see sec IV). Input parameters, atomic number Z, transition energy E_γ and multipolarity are obtained by the

program from the **IDENTIFICATION** record: **DSID**; from the **GAMMA** record: **NUCID**, **E**, **DE**, **M**, **MR** and **DMR** fields of the **G** records. The program will verify the values obtained from the above fields and will generate warning and error messages to help to resolve coding errors. As this function of the program is not designed to carry out full checking of the ENSDF file, the use of FmtChk, prior to use BrIcc is highly recommended. In the following cases BrIcc will not generate new **G** or "**S G**":

(a) Z outside table range - no calculations or no new **G** or "**S G**".

(b) E_γ outside table range - no calculation for that subshell but new records.

(c) B.E.(subshell) $\leq E_\gamma \leq$ B.E.(subshell)+1 keV - no calculation for that subshell and no new records.

For mixed ($\pi L + \pi' L'$) multipolarity transitions the conversion coefficient can be obtained from the following formula:

$$\alpha = \frac{\alpha(\pi L) + \delta^2 \alpha(\pi' L')}{1 + \delta^2}, \tag{5}$$

where $\alpha(\pi L)$ and $\alpha(\pi' L')$ are the theoretical conversion coefficients for the pure multipolarities to be mixed.

The (symmetric) uncertainty of the conversion coefficient, $\Delta\alpha$, is made up of a number of contributions. In some cases $\Delta\alpha$ uncertainty is asymmetric. In this cases the larger absolute value should be adopted for the symmetric uncertainty.

$\Delta\alpha_{theo}$ By comparing the electron conversion coefficients of Band et al., [2002Ba85] to experimental values, Raman et al., [2002Ra45] concluded, that the accuracy of the theoretical α values is in the range of 0-1 %. No information available on the accuracy of the other data tables used by BrIcc (see Sec. IV).
Additional uncertainty can be associated to the cubic spline interpolation used in the same way for all data tables. We adopted a relative uncertainty of 2% for the electron conversion and pair conversion coefficients deduced from the tables. The $\Delta\alpha_{theo}$ is a symmetric uncertainty.

$\Delta\alpha_{DE\_H}$
$\Delta\alpha_{DE\_L}$ The value of the conversion coefficient, α is obtained by interpolation to the theoretical points at the nominal transition energy, E_γ. One can define (asymmetric) uncertainties, $\Delta\alpha_{DE\_H}$ and $\Delta\alpha_{DE\_L}$, deduced from the differences in conversion coefficients obtained for E_γ, $E_\gamma + \Delta E_H$ and $E_\gamma - \Delta E_L$ energies. In the case when either $E_\gamma + \Delta E_H$ or $E_\gamma - \Delta E_L$ is outside of the energy range of the data tables, α values are calculated at the energy limit of the tabulation.

$$\begin{aligned} \Delta\alpha_{DE\_H} &= \alpha(E_\gamma + \Delta E_H) - \alpha(E_\gamma)\,, \\ \Delta\alpha_{DE\_L} &= \alpha(E_\gamma - \Delta E_L) - \alpha(E_\gamma)\,. \end{aligned} \tag{6}$$

If **DE** is a limit, new "**S G**" record will be not generated. In some cases **E** is equal to **DE**, which will be interpreted as only a limit is known for the transition energy and no calculations will be made.

$\Delta\alpha_{DMR\_H}$
$\Delta\alpha_{DMR\_L}$

In the case of mixed transitions, the uncertainties in the mixing ratio, $\Delta\delta_H$ and $\Delta\delta_L$, also contribute to $\Delta\alpha$. Depending on content of **DM** and **DMR** fields, the conversion coefficient, α and the uncertainty associated with **DMR**, $\Delta\alpha_{DMR\_H}$ and $\Delta\alpha_{DMR\_L}$ is determined in one of the.

DMR *is given as symmetric or asymmetric uncertainty.* The conversion coefficient, α is calculated using Eqn. 5 and the uncertainty:

$$\begin{aligned}\Delta\alpha_{DMR\_H} &= \frac{[\alpha(\pi L) + \delta_H^2\alpha(\pi' L')]}{1+\delta_H^2} - \frac{[\alpha(\pi L) + \delta^2\alpha(\pi' L')]}{1+\delta^2}\,,\\ \Delta\alpha_{DMR\_L} &= \frac{[\alpha(\pi L) + \delta_L^2\alpha(\pi' L')]}{1+\delta_L^2} - \frac{[\alpha(\pi L) + \delta^2\alpha(\pi' L')]}{1+\delta^2}\,,\end{aligned} \tag{7}$$

where $\delta_H = \delta + \Delta\delta_H$ and $\delta_L = \delta - \Delta\delta_L$.

DMR *is a lower limit.* The conversion coefficient, α and the uncertainty $\Delta\alpha_{DMR\_H}$ and $\Delta\alpha_{DMR\_L}$ can be obtained as:

$$\begin{aligned}\alpha &= \left[\alpha(\pi' L') + \frac{\alpha(\pi L) + \delta^2\alpha(\pi' L')}{1+\delta^2}\right] \times 0.5\,,\\ \Delta\alpha_{DMR\_H} = \Delta\alpha_{DMR\_L} &= \left|\alpha(\pi' L') - \frac{\alpha(\pi L) + \delta^2\alpha(\pi' L')}{1+\delta^2}\right| \times 0.5\,.\end{aligned} \tag{8}$$

In this case $\Delta\alpha_{DE\_H}$ and $\Delta\alpha_{DE\_L}$ are deduced from the differences in $\alpha(\pi L)$ and $\alpha(\pi' L')$, obtained for energies of E, $E + \Delta E_H$ and $E - \Delta E_L$.

DMR *is an upper limit.* The the conversion coefficient, α and the uncertainty $\Delta\alpha_{DMR\_H}$ and $\Delta\alpha_{DMR\_L}$ can be obtained as:

$$\begin{aligned}\alpha &= \left[\frac{\alpha(\pi L) + \delta^2\alpha(\pi' L')}{1+\delta^2} + \alpha(\pi L)\right] \times 0.5\,,\\ \Delta\alpha_{DMR\_H} = \Delta\alpha_{DMR\_L} &= \left|\frac{\alpha(\pi L) + \delta^2\alpha(\pi' L')}{1+\delta^2} - \alpha(\pi L)\right| \times 0.5\,.\end{aligned} \tag{9}$$

In this case $\Delta\alpha_{DE\_H}$ and $\Delta\alpha_{DE\_L}$ are deduced from the differences in $\alpha(\pi L)$ and $\alpha(\pi' L')$, obtained for energies of E, $E + \Delta E_H$ and $E - \Delta E_L$.

No* MR *is given. For cases when $L \neq L'$ (for example M1+E2 or M1,E2) δ is set to 1.

$$\begin{aligned}\alpha &= [\alpha(\pi L) + \alpha(\pi' L')] \times 0.5\,,\\ \Delta\alpha_{DMR\_H} = \Delta\alpha_{DMR\_L} &= |\alpha(\pi L) - \alpha(\pi' L')| \times 0.5\,.\end{aligned} \tag{10}$$

For cases when $L \equiv L'$ (for example M1,E1) α is calculated using the above equations as δ would be set to 1.

MR *is an approximate value or derived from systematics.* **DMR** contains "AP" or "SY". The conversion coefficient, α is calculated using Eqn. 5 and $\Delta\alpha_{DMR\_H} = \Delta\alpha_{DMR\_L} = 0$. **DCC** field is set to "AP".

A special cases:

The transition energy E *is an approximate value.* **DE** contains "AP". The conversion coefficient, α is calculated using Eqn. 5 and $\Delta\alpha_{DMR\_H} = \Delta\alpha_{DMR\_L} = 0$. **DCC** field is set to "AP".

Combining the $\Delta\alpha_{theo}$, $\Delta\alpha_{DE\_H}$, $\Delta\alpha_{DE\_L}$, $\Delta\alpha_{DMR\_H}$ and $\Delta\alpha_{DMR\_L}$ the uncertainty of the conversion coefficient is given as:

$$\Delta\alpha = \sqrt{(\Delta\alpha_{theo})^2 + (\Delta\alpha_{DE})^2 + (\Delta\alpha_{DMR})^2} \tag{11}$$

where

$$\begin{aligned} \Delta\alpha_{DE} &= (Max(|\Delta\alpha_{DE\_H}|, |\Delta\alpha_{DE\_L})|) \\ \Delta\alpha_{DMR} &= (Max(|\Delta\alpha_{DMR\_H}|, |\Delta\alpha_{DMR\_L})|) \ . \end{aligned} \tag{12}$$

If the total conversion coefficient, $\alpha_{tot} \geq 10^{-4}$, then it will be inserted into the **CC** field of the **G** record.

The program BRICC will generate "**S G**" continuation records if the conversion coefficient is known. If $\alpha_{tot} < 10^{-4}$, α_{tot} and $\Delta\alpha_{tot}$ will be put on the first "**S G**" continuation record. BRICC will append further quantities onto the "**S G**" record(s). If the total intensity field, **TI** on the **G** record is empty (i.e. I_{tot} is not known) the conversion coefficient for the major shells, α_K, α_L, α_M and α_{N+} will be listed. (α_{N+} is the sum of the α_N, α_O, α_P, α_Q, α_R and α_{IPF} conversion coefficients) Additional "**S G**" continuation record(s) will be created to list the α_N, α_O, α_P, α_Q, α_R and α_{IPF} conversion coefficients individually.

If the total intensity, I_{tot} is known, instead if the conversion coefficients, BrIcc will append to the first **S G** continuation record the I_K/I_{tot}, I_L/I_{tot}, I_M/I_{tot} and I_{N+}/I_{tot} intensity ratios. Additional "**S G**" continuation record(s) will be generated for intensity ratios involving the N, O, P, Q, R and S shells and electron–positron pair production. For example for the K-shell we get:

$$\frac{I_K}{I_{tot}} = \frac{\alpha_K}{1 + \alpha_{tot}} \tag{13}$$

and for the uncertainty:

$$\Delta\left(\frac{I_K}{I_{tot}}\right) = \frac{I_K}{I_{tot}} \times \sqrt{\left(\frac{\Delta\alpha_K}{\alpha_K}\right)^2 + \left(\frac{\Delta\alpha_{tot}}{\alpha_{tot}}\right)^2} \ . \tag{14}$$

There is some covariance between α_K and α_{tot}, which has been neglected in the equation.

IV. DATA TABLES

The data tables, large ASCII files, are stored in different subdirectories, located below the *main directory*, where the executable programs and the direct access index and ICC files are located. The only environment variable, which has to be set is the %BrIccHome% pointing to the *main directory*. The data tables used by BrIcc are summarized in Table I.

A. Dirac-Fock Internal Conversion Electron Coefficients

Data set label: `BrIcc`
Sequential file: `%BrIccHome%\Data\BrIcc\BrIcc.txt`
Reference: [2002Ba85] and [2004KiXX]

TABLE I: Theoretical tabulations of internal conversion coefficients and electronic factors used by BrIcc.

	Z	Shells or IPF	L	E_γ [keV][a]
Internal conversion coefficient α_{ic}				
[2002Ba85]	10–126[b]	All	1–5	ε_{L1}+1–2000
This work	10–95	All	1–5	ε_{ic}+1–6000
Pair conversion coefficient α_{IPF}				
[1979Sc31]	0–100[c]	IPF	1–3	1100–8000
[1996Ho21]	50–100	IPF	1–3	1100–8000
Electronic factor Ω(E0)				
[1969Ha61]	30–102	K[d], L_1^e, L_2^e	0	ε_K+6–1500
[1970Be87]	40–102	K, L_1, L_2	0	51–2555
[1986PaZM]	8–40	K[f], IPF	0	511–12775

[a] ε_{ic} is the binding energy for the ic–shell.
[b] Used for $Z > 95$
[c] Used for $Z < 50$
[d] Not used
[e] Used for $Z < 40$
[f] Used for $Z < 40$

Z-range: 10-126
Energy-range: 1 keV to 6000 keV
Shells: all shells and Total conversion coefficient, however BRICC will deduce the total conversion coefficient by adding all sub–shell, as well as the electron-positron pair conversion coefficients.
Multipolarity: E1-E5, M1-M5
Note: The current version of the Dirac-Fock ICC table is based on calculations **without taking into account** the effect of **the hole**. It is assumed that apart some special cases (for example 80.22 (2) keV M4 transition in $^{193}_{77}Ir$), the conversion coefficient will not change significantly by taking into account the hole.

The ASCII sequential file has been generated from the published supplementary file of [2002Ba85] and from additional calculations [2004KiXX].

Additional data points were calculated using the a slightly modified version of the original code [2002Ba85]. The extended tables now cover an energy range of 1 to 6000 keV compare to the original range of L1 binding + 1 keV to 2000 keV. The modifications of the original program required to increase the numerical accuracy of the calculations for certain outer shells (M4–shell for Z=23, N4 and O4 for Z=21, 58, 64) and for higher energies. There are a few cases (N6-shell for Z=59–75, and N7-shell for Z=63–75), where the conversion coefficient is non–monotonous (oscillating) as a function of transition energy. It is assumed, that this it caused by limitation in the numerical methods used in the program. For these cases calculated ICC's for $E_\gamma > 400$ keV are not given.

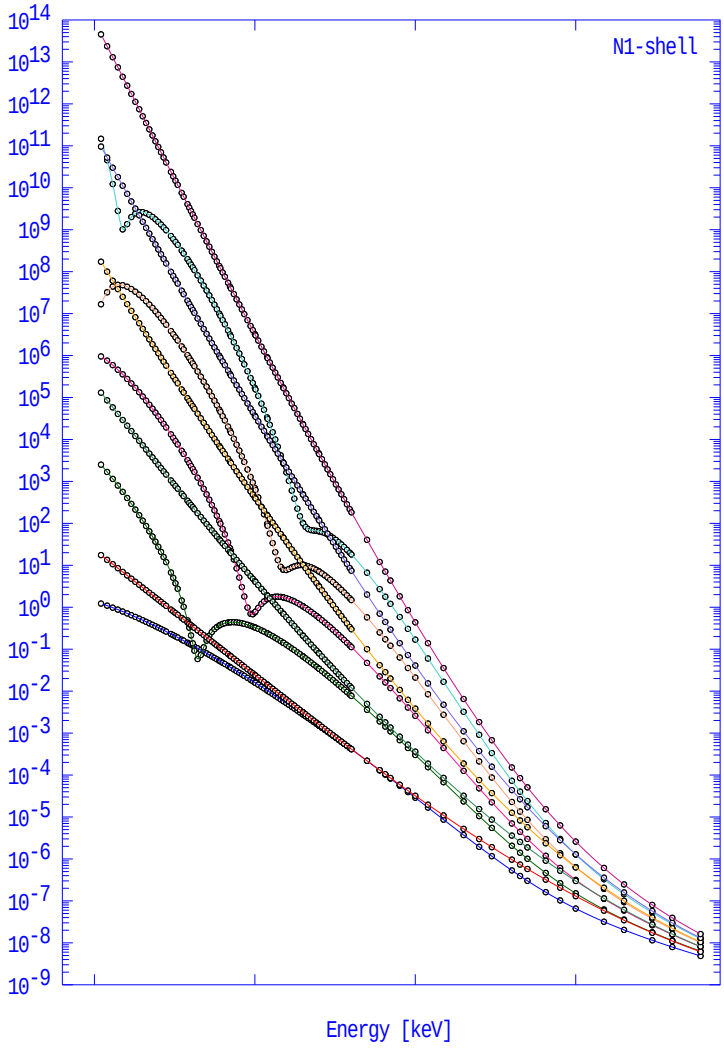

FIG. 1: Conversion coefficients for $N1$–shell in ^{64}Zn. Open circles are calculated values, lines representing interpolated values.

Representative conversion coefficients are shown in Fig. 1. For lighter element it was suggested [2002Ba85, 2002Ra45], that the conversion coefficient for some of the $s_{1/2}$ shells are not monotonous. They are attributed to cancelation effects of the leading matrix elements causing sharp reduction of the conversion coefficients. The so called "resonance"–like effect is clearly visible on Fig. 1 at 4.5 keV for $\alpha_{N1}(E2)$ for ^{64}Zn. Similar features can be observed for E3-E5 multipolarities at higher energies. Another type of irregularities are emerging from the Fig. 1 at very low energies. This is a threshold irregularity effect and is assumed different in character. Both effects have been explored further in our recent studies [2004KiXX] in order to establish empirical relation between the position of the irregularity, defined as the transition energy, where the conversion coefficient take the minimum value and the atomic number Z. Fig. 2 shows the results together with the proposed relations.

These empirical relations has been used to increase the density of the mesh points in the "resonance"–like and threshold irregularity regions in order to increase the accuracy of the

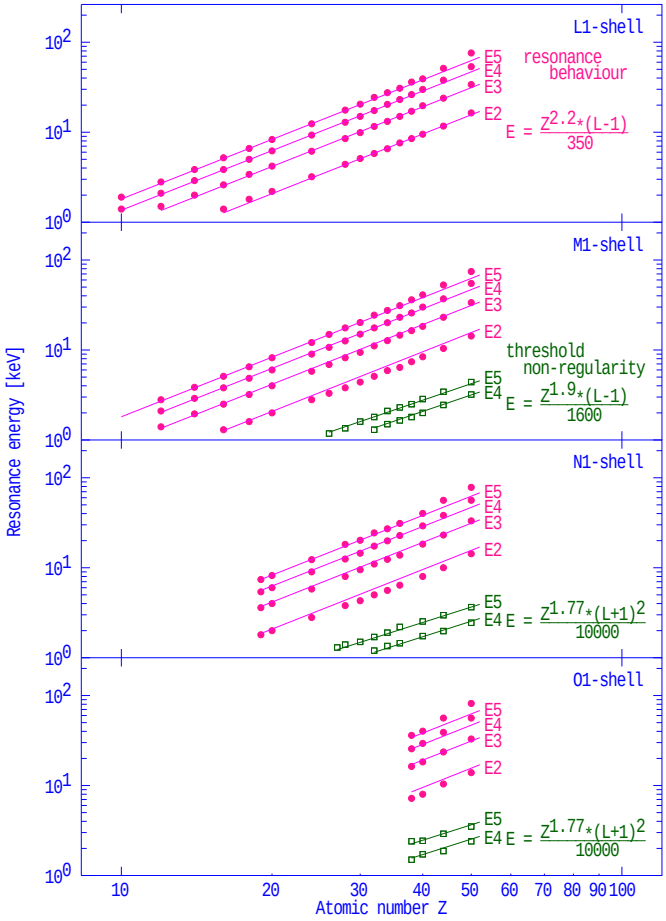

FIG. 2: Position of the "resonance"– and threshold non–regularity regions as a function of atomic number of Z. Note the logarithmic scale on both axes. Approximate relations are also displayed.

numerical interpolation. This is illustrated in Fig. 3.

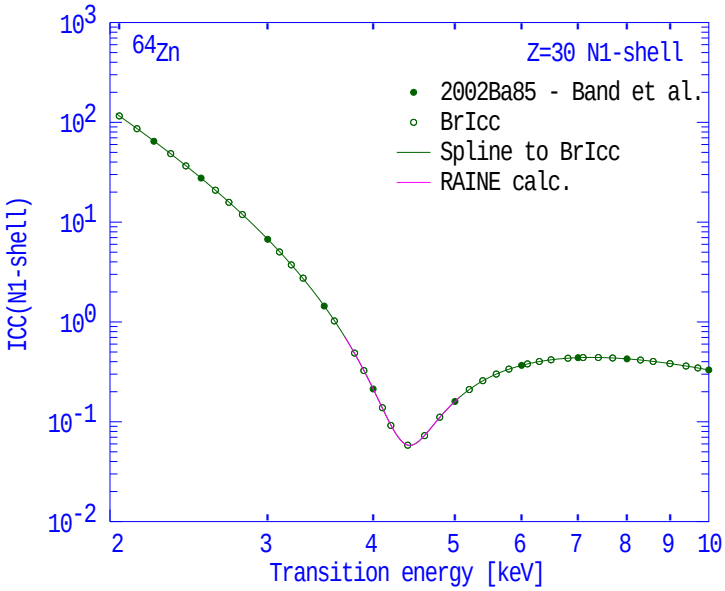

FIG. 3: E2 conversion coefficients for the N1–shell in ^{64}Zn in the "resonance"–like region. Tabulations of [2002Ba85] (filled circles), [2004KiXX] (open circles) are shown with calculations with the modified version of the [2002Ba85] code (RAINE). Cubic spline interpolated values to the present BrIcc table are also shown.

B. Conversion Coefficients for Electron-Positron Pairs

Sequential file: `%BrIccHome%\Data\PCC\PCC.txt`
Energy range: 1100-8000 keV
Z-range: 1,2,3,...100
Multipolarity: E1-E3, M1-M3 (Please note dummy zero values inserted in E4-E5 and M4-M5 columns of the ASCII file to maintain compatibility with BrIcc.txt file.)

This data set is based on two tabulations from the same group:

(a) Data set label: ScPcc
Reference: `1979Sc31` [1979Sc31]
Used for $Z < 50$

(b) Data set label: HoPcc
Reference: `1996Ho21` [1996Ho21]
Used for $Z \geq 50$

The original printed tables were digitized using an optical scanner and character recognition software. The distributed files may contain errors. Please report them to the author for correction.

The original tabulations were given for Z=0, 10, 20, ...100. Cubic spline interpolation was used to obtain values for intermediate Z values.

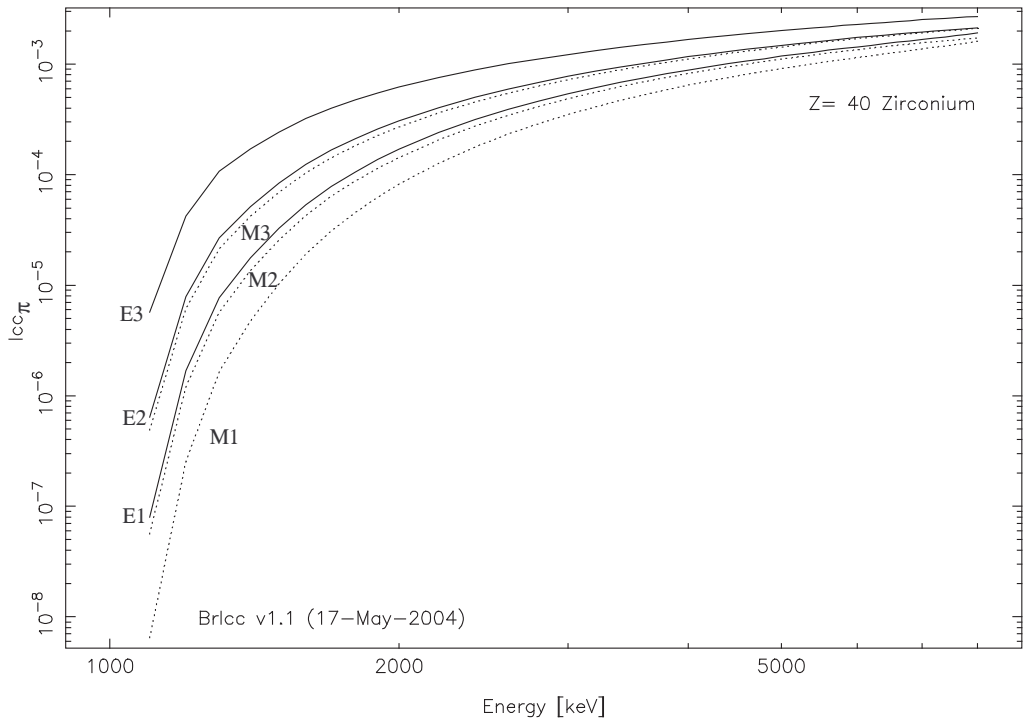

FIG. 4: Calculated electron–positron pair conversion coefficients in ^{90}Zr. Full lines are for E1-E3 and dotted lines are for M1-M3 multipolarity. Lines connecting tabulated points.

C. Electronic factors for E0 transitions

Three different tabulations, listed below, are partially overlapping in terms of atomic number Z, transition energy. The subset of data included into the BRICC data base is indicated in each case. The original printed tables were digitized using an optical scanner and character recognition software. The distributed files may contain errors. Please report them to the author for correction.

(a) Data set label: `HsOmg`
Sequential file: `%BrIccHome%\Data\HsOmg\HsOmg.txt`
Reference: 1969Ha61 [1969Ha61]
Z-range: 30,34,38,42 (original table). Intermediate values for Z=32,36,40 were obtained by cubic spline interpolation.

Tabulated values of $A(E0, Z, k)$ have been converted to $\Omega(Z, k)$ using the following formulae:
$\Omega(Z, k) = \frac{8\pi m_\circ c^2}{\hbar} A(E0, Z, k)k$.

Energy range: K-shell: 15.9(26.2)-1500 keV, L1-Shell: 7.4(9.1)-1500 keV, L2-shell: 7.2(8.8)-1500 keV
Electron shells: K, L1, L2
BrIcc data base includes: L1 and L2 shells and Z=30,32,..38.

(b) Data set label: BeOmg
Sequential file: `%BrIccHome%\Data\BeOmg\BeOmg.txt`
Reference: 1970Be87 [1970Be87]
Z-range: 40,42,44,...102
Energy range: 51.1-2555.0 keV
Electron shells: K, L1, L2
BrIcc data base includes: all data

(c) Data set label: PaOmg
Sequential file: `%BrIccHome%\Data\PaOmg\PaOmg.txt`
Reference: 1986PaZM [1986PaZM]
Z-range: 8,10,12,...40
Energy range: 511-12775 keV
Electron shells: K, IPF (BrIcc treats IPF coefficients in the same way as the electron shells.)
BrIcc data base includes: all data, except K-shell for Z=40

V. BLDBRICC PROGRAM

This program reads the BldBrIcc.dat file, which contains the file names of the ASCII data files, listed in the previous chapter. The first record of the BldBrIcc.dat files is the home directory of BrIcc.

BldBrIcc.dat: (input) Contains the home directory of BrIcc and the file names of the ASCII data files, listed in the previous chapter.

BRICC.IDX: (output) The Icc index file containing 2048 bytes long records for elements from Z=1 to 126. Each record contains the atomic number, the atomic mass used to calculate the conversion coefficient, the chemical symbol and the first record number in the BRICC.ICC file where any of the 41 "shells" (α_K, α_{L1}, ... α_{R2}, α_{total}, α_{IPF}, Ω_K, Ω_{L1}, Ω_{L2} and Ω_{IPF}) is starting. The record number is set to zero if no data are available for that shell.

BRICC.ICC: (output) The ICC data file. Each record is 44 bytes long and contains the transition energy and a maximum of 10 conversion coefficients (E1-E5,M1-M5) or just a single electronic factor.

Terminal dialog: The program will look for and open the input file. The program will report if the sequential data files were successfully opened and will report the progress (see Fig V).

Typical execution time on a IBM PC (2.4 GHz CPU, 512 Mbyte RAM, Windows XP) is less than a minute.

```
BldBrIcc v1.2 22-Sep-2004 creates BrIcc.idx and BrIcc.icc files
-------------------------------------------------------------------------------
Data sets to process:
BrIcc     \Data\BrIcc\BrIcc.txt
Pcc       \Data\Pcc\Pcc.txt
HsOmg     \Data\HsOmg\HsOmg.txt
BeOmg     \Data\BeOmg\BeOmg.txt
PaOmg     \Data\PaOmg\PaOmg.txt
-------------------------------------------------------------------------------
Processing data:
Created lookup file: BrIcc.idx
Created direct access data file: BrIcc.icc
DataSet    Z Shell   Record
-------------------------------------------------------------------------------
ScPcc      1 IPF          1
ScPcc      2 IPF         41
ScPcc      3 IPF         81
ScPcc      4 IPF        121
ScPcc      5 IPF        161
ScPcc      6 IPF        201
ScPcc      7 IPF        241
ScPcc      8 IPF        281
PaOmg      8 K          321
...
...
...
BrIcc    126 R1      123501
BrIcc    126 R2      123518
BrIcc    126 Total   123535
-------------------------------------------------------------------------------
bricc.icc and bricc.idx files were created
```

FIG. 5: BLDBRICC terminal dialog.

VI. BRICC PROGRAM

This program calculates the internal conversion electron and electron-positron pair coefficients and electronic factors for E0 transitions by cubic spline interpolation on the Log-Log scale.

"BrIccHome": The home directory of the program is defined by setting the value of the "BrIccHome" environment variable to point to the directory, where the program is located. Consult with the documentation of the operating system, how to set environment variables.

Input files: Data files, created by BLDBRICC, are

%BrIccHome%\BrIcc.idx (ICC index file)

and

%BrIccHome%\BrIcc.icc (binary file of ICC's).

Terminal dialog: The BRICC program can be used in three different ways: (a) interactively to calculate ICC, (b) to generate GAMMA and SG records for an ENSDF file, (c) insert (merge) newly created records with existing ENSDF file.

A. BRICC – interactive use

Program execution: `BRICC<cr>`. It will invoke the program with default values of Z=70 (Ytterbium) and E_γ=279.717 keV.

Terminal dialog: The program uses 109 characters long lines to report conversion coefficient for E1-E5 and M1-M5 multipolarities, see Fig. 6. Consult with the documentation of the operating system used to set the width of the terminal window accordingly. A list of interpolated conversion coefficients for all major and sub–shells, for electron–positron pair creation, etc.

Parameter input:

Chemical symbol: Maximum of 2 characters. BrIcc will load the appropriate data set from disk.

Atomic number: Character Z followed by an integer, between 1 and 126 will be interpreted as an atomic number. BrIcc will load the appropriate data set from disk.

Transition energy: A positive number in free format, in keV. For example: 124, 124.0, 1.24E+2.

SUBShell: Will enable or disable the list of subshell ratios.

EXIT: Terminates the program execution.

Error handling: The program will reject an input string, which could not be interpreted as transition energy, chemical symbol, atomic number or subshell toggle on/off.

B. BRICC – ENSDF evaluation tool

Program execution: `BRICC` *ENSDF-file*`<cr>`.
The ENSDF file name is passed as program argument. Sample input file: BRICC.ens. NOTE: The input *ENSDF-file* data should not be modified before running the code in the MERGE mode (see sec. VI C). NOTE: Set the working directory (path) on the Command prompt (Windows) or on the Console (Linux/UNIX) to the directory where the *ENSDF-file* data is. This will allow to have all input and output files in the same directory.

Output files:

```
-------------------------------------------------------------------------------------------------------------
Z= 70 Ytterbium              BrIcc v1.2 (22-Sep-2004)
Transition energy: 279.717 keV
Shell  E_e                                                 I C C
       [keV]       E1       M1       E2       M2       E3       M3       E4       M4       E5       M5
-------------------------------------------------------------------------------------------------------------
Tot             2.36E-02 1.90E-01 9.08E-02 8.04E-01 4.22E-01 2.98E+00 2.25E+00 1.16E+01 1.24E+01 4.90E+01
K        218.38 1.98E-02 1.59E-01 6.34E-02 6.37E-01 1.88E-01 2.10E+00 5.59E-01 6.83E+00 1.70E+00 2.22E+01
L1       269.23 2.34E-03 2.19E-02 7.45E-03 1.08E-01 2.57E-02 4.53E-01 1.06E-01 1.89E+00 4.98E-01 7.92E+00
L2       269.74 3.02E-04 1.78E-03 8.32E-03 1.35E-02 1.02E-01 8.36E-02 8.08E-01 4.68E-01 5.29E+00 2.48E+00
L3       270.77 3.04E-04 2.33E-04 5.36E-03 7.57E-03 5.10E-02 1.30E-01 3.59E-01 1.24E+00 2.18E+00 9.41E+00
L-tot           2.95E-03 2.39E-02 2.11E-02 1.29E-01 1.78E-01 6.67E-01 1.27E+00 3.60E+00 7.97E+00 1.98E+01
M1       277.32 5.07E-04 4.85E-03 1.63E-03 2.46E-02 5.87E-03 1.07E-01 2.60E-02 4.63E-01 1.31E-01 2.01E+00
M2       277.54 7.20E-05 4.37E-04 2.04E-03 3.37E-03 2.54E-02 2.12E-02 2.06E-01 1.21E-01 1.37E+00 6.52E-01
M3       277.76 7.44E-05 5.80E-05 1.35E-03 1.95E-03 1.30E-02 3.46E-02 9.30E-02 3.40E-01 5.70E-01 2.65E+00
M4       278.14 1.11E-06 1.00E-06 1.10E-05 2.25E-05 1.50E-04 4.74E-04 4.05E-03 6.27E-03 6.56E-02 6.34E-02
M5       278.19 1.40E-06 8.16E-07 8.50E-06 3.85E-06 1.41E-04 1.21E-04 2.81E-03 4.20E-03 3.71E-02 7.13E-02
M-tot           6.56E-04 5.35E-03 5.04E-03 3.00E-02 4.46E-02 1.63E-01 3.32E-01 9.35E-01 2.18E+00 5.45E+00
N1       279.23 1.19E-04 1.14E-03 3.83E-04 5.84E-03 1.39E-03 2.56E-02 6.27E-03 1.12E-01 3.22E-02 4.90E-01
N2       279.32 1.64E-05 1.00E-04 4.66E-04 7.74E-04 5.83E-03 4.88E-03 4.75E-02 2.80E-02 3.18E-01 1.52E-01
N3       279.37 1.68E-05 1.32E-05 3.08E-04 4.46E-04 2.98E-03 7.97E-03 2.13E-02 7.88E-02 1.31E-01 6.19E-01
N4       279.52 2.58E-07 2.33E-07 2.56E-06 5.25E-06 3.50E-05 1.11E-04 9.51E-04 1.48E-03 1.55E-02 1.50E-02
N5       279.53 3.21E-07 1.87E-07 1.94E-06 8.84E-07 3.26E-05 2.82E-05 6.54E-04 9.82E-04 8.66E-03 1.68E-02
N6       279.71 3.23E-10 2.04E-10 1.99E-09 1.28E-09 1.74E-08 2.54E-08 2.02E-07 8.97E-07 7.37E-06 1.96E-05
N7       279.71 4.73E-10 2.52E-10 2.49E-09 1.04E-09 1.38E-08 5.04E-09 2.04E-07 1.32E-07 6.44E-06 7.16E-06
N-tot           1.53E-04 1.26E-03 1.16E-03 7.06E-03 1.03E-02 3.86E-02 7.67E-02 2.21E-01 5.06E-01 1.29E+00
O1       279.66 1.73E-05 1.67E-04 5.58E-05 8.52E-04 2.04E-04 3.75E-03 9.20E-04 1.64E-02 4.73E-03 7.19E-02
O2       279.68 1.93E-06 1.18E-05 5.51E-05 9.17E-05 6.91E-04 5.79E-04 5.64E-03 3.32E-03 3.78E-02 1.80E-02
O3       279.69 1.85E-06 1.44E-06 3.38E-05 4.90E-05 3.28E-04 8.78E-04 2.34E-03 8.70E-03 1.44E-02 6.84E-02
O-tot           2.11E-05 1.80E-04 1.45E-04 9.93E-04 1.22E-03 5.20E-03 8.90E-03 2.84E-02 5.69E-02 1.58E-01
P1       279.71 1.00E-06 9.64E-06 3.23E-06 4.93E-05 1.18E-05 2.17E-04 5.32E-05 9.48E-04 2.74E-04 4.17E-03
P-tot           1.00E-06 9.64E-06 3.23E-06 4.93E-05 1.18E-05 2.17E-04 5.32E-05 9.48E-04 2.74E-04 4.17E-03
Electronic Factor  E0
K               3.96E+10
L1              5.96E+09
L2              8.38E+07
TranEner / ChemSymb(2 char) / SUBShell/ EXIT [279.717] >
```

FIG. 6: BRICC interactive terminal dialog.

Calculation report: Complete report of calculations. Default file: BRICC.LST.

New G/SG records: New G/2 G records generated by the program. This is used as input to the program running as a utility to MERGE records. Default file: CARDS.NEW.

G/SG (New/Old) comparison report: Comparison of new and old G/2 G records. Default file: COMPAR.LST.

The program will process all data sets in the ENSDF file, exept the IONIZED ATOM, COMMENTS and REFERENCES data sets. In the calculation report gamma–rays of a data set will be listed by increasing transition energy for each data set. (Note: BrIcc will create a binary file, BrIcc.tmp to store temporarily calculation reports.)

Different type of messages are given on the console window and in the caclulations report file. These messages are designed to inform the evaluator and to asist to resolve conflicts or errors in the ENSDF file.

$< I >$ For information only. Calculations of new ICC's are carried out and new **G** and **s G** cards are generated.

$< W >$ Warnings are given if the ENSDF records are correct, but some of the fields contains non-unique information. In some cases when calculations of the ICC values could not be carried out , which is indicated in the message. For example the **M** field contains $D+Q$.

$< E >$ An error is detected either on the **G**, or **G**–continuation, or on the **IDEN**tification card. As the program progressively scans through these records, the rest of the record will not be scanned.

$< F >$ Reserved for indicating, that BrIcc encountered an internal programming error. In such a case please forward the ENSDF data set and the error message to the authors.

A typical terminal dialog can be seen in Fig. 7.

```
C:\ENSDF>bricc ba1978bo18.ens<cr>
BrIcc v1.2 (22-Sep-2004) calculates conversion coefficients
 (for electron conversion and pair production)
          and E0 electronic factors
        using cubic spline interpolation
Index file: C:\Program Files\BrIcc\BrIcc.idx
ICC file: C:\Program Files\BrIcc\BrIcc.icc
Input ENSDF file: ba1978bo18.ens
Output Files
  Complete calculations report, (Def: BrIcc.lst):
  List conversion coefficients for all subshells (Def. N):
  Calculate conversion coefficients for all transitions (Def. N):
  New G/SG records, (Def: Cards.new):
  G/SG (New/Old) comparison report, (Def: Compar.lst):
      Processing a new data set
     1 : 172YB    172LU EC DECAY (6.70 D)
   104 : 172YB  G 155.87    7 0.032   7 M1(+E2)   0.7     LT    0.90   6
   107 : 172YBS G KC=0.72 8$LC=0.139 18$MC=0.032 5$NCC+=0.0085 12
                                                 **************
          WARNING - Non-standard data will be over-written
   109 : 172YB  G 174.671   190.180   8
   112 : 172YB  G 348.83    220.015   11
   113 : 172YB  G 596.75    150.102   23
   114 : 172YB  G 604.65    190.050   23
   115 : 172YB  G 990.75    150.12    6 D,E2
   ...
   ...
   1251 : 172YB  G 770.4     2 0.012   2
   1257 : 172YB  G 588.3     2 0.0093  19
   1259 : 172YB  G 2197.3    2 0.006   3
   1265 : 172YB  G 1932.0    2 0.0019  5
   1267 : 172YB  G 2211.4    2 0.0034  6
  BrIcc finished processing ba1978bo18.ens
  Processed:
  #DataSets     :     1
  #AllRecords   :  1269
  #GammaRecords :   286
  #Warnings     :     2
  Skipped:
  #DataSets     :     0
```

FIG. 7: BRICC – ENSDF tool terminal dialog.

C. BRICC – ENSDF utility to merge records

This program merges the new (corrected) G-records with the input ENSDF data set to create an updated data set.

Program execution: `BRICC` *ENSDF-file* merge`<cr>`.
The ENSDF file name is passed as program argument.

Input file: Correction file of G-records created by BRICC. Default file: CARDS.NEW

Output files: Updated file (ENSDF format). Default file: CARDS.MRG

Terminal dialog: (see Fig. 8)

```
C:\ENSDF>bricc Ba1978Bo18.ens merge
BrIcc v1.2 (22-Sep-2004) calculates conversion coefficients
 (for electron conversion and pair production)
           and E0 electronic factors
        using cubic spline interpolation
Index file: C:\Program Files\BrIcc\BrIcc.idx
ICC file: C:\Program Files\BrIcc\BrIcc.icc
  New G/SG cards, (Def: Cards.new):
  Output file of merged old and new cards, (Def: Cards.mrg):
Merge operation completed
```

FIG. 8: BRICC – ENSDF merge tool terminal dialog.

VII. TESTING OF THE BRICC PROGRAM PACKAGE

To provide a test of the ENSDF tool portion of BrIcc a subset of data was extracted from the ENSDF database at the NNDC. This consisted of all IT decay datasets (total of 1773 transitions) and the β– or electron-capture dataset containing the most GAMMA records for each Z (total of 17637 γ's). It was felt that the IT data would provide a good test of the higher multipolarities and lower γ-ray energies and the β– or electron-capture data should provide higher γ–ray energy testing. The data were processed using version 1.2 of BrIcc (September 12, 2004). The *Compar.lst* output from the program was parsed to obtain the original input and new output values of the total and K through NC+ shell conversion coefficients. All γ-rays where the total conversion coefficient (α_{tot}) was missing from the input or new output were excluded from further testing. The ratios of the ENSDF total conversion coefficient to the BrIcc total conversion coefficient were analyzed to identify possible problems in the BrIcc program. This consisted of looking at data for ratios that were outside the range of 0.9 through 1.1. Where available, the results from version 1.13f of HSICC (October 9, 2001) were used as an aid in the analysis. This process consisted of several parts:

1. If BrIcc and HSICC were in good agreement or there were no HSICC data, the original ENSDF data were looked at.

2. If an obvious error was found in ENSDF, the data were excluded from the comparison. If there was explicit documentation that the ENSDF conversion was anomalous, the data were retained (the largest ratio was an anomalous E1 with a value of 8.1). If no obvious errors were found in ENSDF and no problems could be identified in BrIcc, the data were also retained.

3. The BrIcc.lst output was checked if:

   (a) If BrIcc and HSICC values were discrepant.

   (b) If HSICC data were not available and no obvious errors could be identified in the ENSDF data.

   Identified problems were remedied in the program and were excluded from further comparison. Other cases were analyzed for some generic characteristics. Two of these are:

   (a) Round-off problems. These typically occurred for M1,E2 and M1+E2 transitions with no mixing ratios resulting in an uncertainty greater than 25 in the last two significant digits and are grouped in the 1.1 to 1.2 range.

   (b) Internal electron-positron pair formation. Above the pair production threshold ($E_\circ = 2m_e c^2$), the ratios started descending below 1.0 in a fairly consistent manner as a function of increasing E_γ. This appears to be caused by the internal pair coefficient becoming dominant as a function of increasing energy. Also, with a few exceptions, it was noticed that the E1 and M1 transitions were grouped into two distinct patterns with the M1 transition ratios higher than the E1 and both decreasing in a consistent manner.

The final set of data from the above analysis is shown in Fig. 9. A similar process is now in progress to check the K through NC+ shell conversion coefficients.

VIII. COMPILING AND RUNNING THE PROGRAMS

The BLDBRICC and BRICC programs have been developed using Fortran 90 compiler on a Windows system. Special considerations were given to avoid using operating system specific routines. In some places so called compiler directive structures were used to adopt platform specific features.

External libraries used to develop the code:

NSDFLIB library Nuclear Structure Data File Library, developed by the National Nuclear Data Center, Brookhaven National Laboratory and can be downloaded from *http : //www3.nndc.bnl.gov/toolspublications/toolspublications.html#sdtools*

F2KCLI library a free implementation of the proposed Fortran F2003 command line interface, developed by Interactive Software Services Ltd. and can be downloaded from *http : //www.winteracter.com/f2kcli*

On Windows platform the f2kcli.f90 source code has been modified, as the program failed to detect embedded blank character between double quotation (") marks. The modified version of the source code (f2kcli.f90) is now in the source directory.

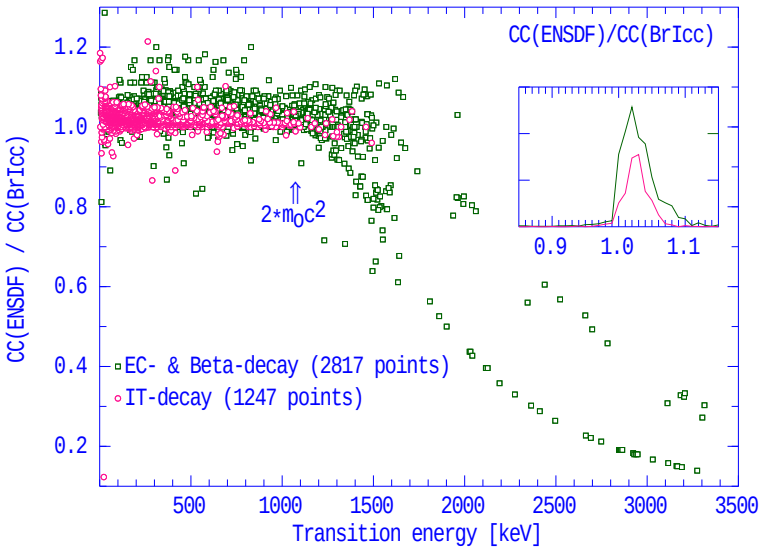

FIG. 9: Comparison of total conversion coefficients nuclear transitions of selected EC and β–decay (squares) and IT–decay (circles) data sets from the ENSDF data file compared with values calculated using BrIcc. The insert shows the frequency distribution of the CC(ENSDF)/CC(BrIcc) ratios.

The BRICC distribution files do not contain the source code of the BrIcc programs. The instructions on compiling and linking the program on various platforms are designed to assist future developers.

A. Windows systems using CVF 6.6c compiler

The 32-bit Windows version of the programs has been developed using Compaq Visual Fortran version 6.6c with Fortran console application presets. The programs are compatible with Win9x/NT/ME/2000/XP operating systems. Due to different implementation of the command prompt, on Windows 95 and 98 system the console buffer is limited to a maximum of 50 lines.

To locate data files both programs, BldBrIcc and BrIcc use the *BrIccHome* environment variable pointing to the directory, where the BrIcc.idx and BrIcc.icc files are. In a typical installation, this directory is $C:\backslash Program\ Files\backslash BrIcc$. To enable the execution of BrIcc on the Command Prompt window from any working directory, the installation directory should be included into the Path variable.

The self-extracting program archive will install the BrIcc program, the data files and the manual into a directory which can be selected during installation. On Windows NT, ME, 2000 and XP operating system the installation script will also set the "BrIccHome" and "Path" environment variables. On Windows 95 and 98 platforms the following two lines have to be added to the Autoexec.bat file:

```
set BrIccHome=<InstallDir>
set Path=%Path%;<InstallDir>
```

<InstallDir> is the directory where the program has been installed.

To upgrading the program, please uninstall the previous version using the "Uninstall" link provided in the BrIcc program group.

B. Compaq Tru64 UNIX using Digital F90 compiler

Use the make file in the source directory to compile and link the bldbricc and bricc programs by typing "*make*". Note on Unix system a lower case convention has been adopted for the executables. The script for the make program, called *Makefile* is in the source directory, just below the main program directory. The programs can be built separately using "*make bldbricc*" and "*make bricc*". Executables are placed in the directory above the source directory. The command "*make clean*" to remove the object files after compilation.

BldBrIcc and BrIcc require an environment variable BrIccHome to be set in order to locate the data files. For example, if the main directory is /usr/local/bin/bricc, the following shell commands can be used:

```
{BrIccHome=/usr/local/bin/bricc}
{export BrIccHome}
```

C. Linux using LF95

Use the make file in the source directory to compile and link the bldbricc and bricc programs by typing "*make*". Note on Linux system a lower case convention has been adopted for the executables. The script for the make program, called *Makefile* is in the source directory, just below the main program directory. The programs can be built separately using "*make bldbricc*" and "*make bricc*". Executables are placed in the directory above the source directory. The command "*make clean*" to remove the object files after compilation.

BldBrIcc and BrIcc require an environment variable BrIccHome to be set in order to locate the data files. For example, if the main directory is /usr/local/bin/bricc, the following shell commands can be used:

```
{BrIccHome=/usr/local/bin/bricc}
{export BrIccHome}
```

TABLE II: ENSDF **G** record containing information on the nuclear transitions. Taken from J.K. Tuli [2001TuXX]

Field	Name	Description
1-5	NUCID	Nuclide identification
6		Blank or continuation character
7		Must be blank
8	G	Letter G is required
9		Must be blank
10-19	E	Energy of the γ-ray in keV
20-21	DE	Standard uncertainty in E
22-29	RI	Relative photon intensity
30-31	DRI	Standard uncertainty in RI
32-41	M	Multipolarity of transition
42-49	MR	Mixing ratio, δ.
50-55	DMR	Standard uncertainty in MR
56-62	CC	Total conversion coefficient
63-64	DCC	Standard uncertainty in CC
65-74	TI	Relative total transition intensity
75-76	DTI	Standard uncertainty in TI
77	C	Comment FLAG
78	COIN	Letter C denotes placement confirmed by coincidence. Symbol ? denotes questionable coincidence.
79		Blank
80	Q	The character ? denotes an uncertain placement

TABLE III: ENSDF GAMMA continuation record. Taken from J.K. Tuli [2001TuXX]

Field	Name	Description
1-5	NUCID	Nuclide identification
6		Any alphanumeric character other than 1. **Note:** 'S' is reserved for records not shown in the Nuclear Data Sheets
7		Must be blank
8	G	Letter G is required
9		Must be blank
10-80	DATA	Allowed quantities The general form of a data entry as described on p. 33 of [2001TuXX] is: $< quant >< op >< value > [< op >< value >][< ref >]\$$ **G continuation record – any character other than 1 or S in column 6** E, DE, RI, DRI, M, MR, DMR, CC, DCC, TI, DTI, C, COIN, Q, BE1, BE2, ...; BE1W, BE2W, ...; BM1,BM2, ...; CE, CEK, CEL, ...; CEL1, ...; ECC, EKC, ELC, EL1C, ...; FL, FLAG **S G records – character 'S' in column 6** BrIcc will scan the existing "**S G**" records and validate and will replace the Data entries if they comply with the following rules: (a) **TI** not given in **G** record and **M** is known On the first "**S G**" record: **CC**, **KC**, **LC**, **MC**, **NC+** (electron conversion coefficients) On additional "**S G**" records: **NC**, **OC**, **PC**, **QC** and **RC** (electron conversion coefficients) and **IPC** (pair conversion coefficient[a]) Obsolete data entries also verified and will be removed, including: **MC+**, **M+** and **N+**. (b) **TI** given in **G** record and **M** is known On the first "**S G**" record: **CC** and **K/T**, **L/T**, **M/T**, **N+/T** (intensity ratios) On additional "**S G**" records: **N/T**, **O/T**, **P/T**, **Q/T** and **R/T** and **IP/T** (internal pair to total intensity ratio[a]) Obsolete data entries also verified and will be removed, including: **M+/T** and a warning will be issued. Any other data entry or text will be copied onto new "**S G**" records and will be inserted as new.

[a] – *To be declared in ENSDF dictionary and manual.*

TABLE IV: Typical values of the multipolarity (M), Mixing ratio (MR) and uncertainty (DMR) fields of the **G** record

M	MR	DMR	Multipolarity assignment
M1			Definite M1
(M1)			Uncertain M1
[E2]			Assumed E2
M1+E2	2.5	7	M1 plus E2, definite $\delta(E2/M1) = 2.5\,(7)$, symmetric uncertainty
M1+E2	+0.014	+15-12	Mixed M1 plus E2, definite, $\delta(E2/M1) = +0.14^{+15}_{-12}$, asymmetric uncertainty
M1+E2	2.5	LE	M1 plus E2, definite $\delta(E2/M1) \leq 2.5$, upper limit
[M1,E2]			Assumed mixed M1 plus E2, assumed $\delta(E2/M1) = 1$ with no uncertainty
E1+M2+E3	+0.012	+6-4	Mixed E1 plus M2 plus E3, definite, $\delta(M2/E1) = +0.012^{+6}_{-4}$ (E3 multipolarity component omitted)
[E1,M2,E3]			Assumed mixed E1 plus M2 plus E3, assumed $\delta(M2/E1) = 1$ (E3 multipolarity component omitted)
E0+M1+E2	+2.7	+3-1	Mixed E0 plus M1 plus E2, definite, $\delta(E2/M1) = +2.7^{+3}_{-1}$ $q(E0/E2) = 0.24\,(3)$ given in the GAMMA cont. record[a]

[a] *To be declared in ENSDF dictionary and manual.*

[1969Ha61] R.S. Hager and E.C. Seltzer, Nucl. Data Tables, **6**, (1969) 1

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